NASA'S COSMOS – Ken Lang

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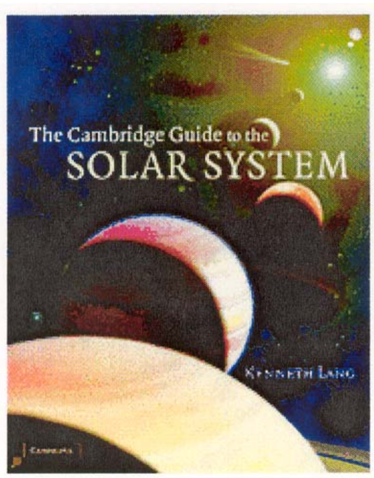
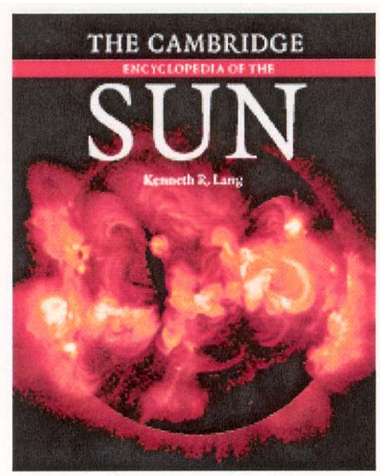
Welcome to NASA's Cosmos

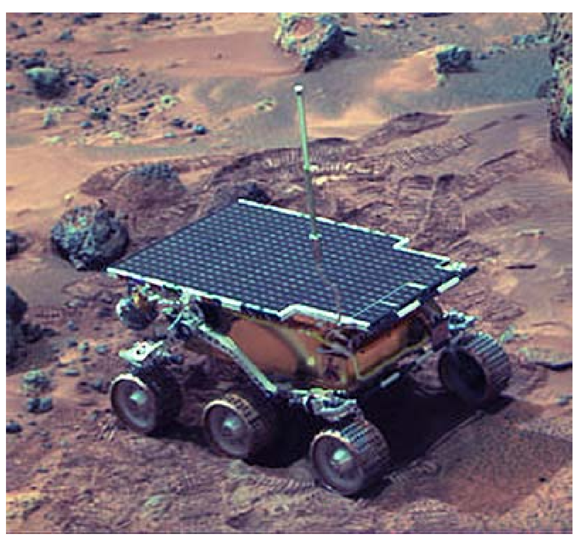
NASA's Cosmos provides comprehensive accounts of the most recent discoveries about the planets, their satellites, the Sun, and other bodies in the solar system, based primarily on NASA space missions. Funding for this site is provided by NASA's Applied Information Systems Research Program, and the University College of Citizenship and Public Service at Tufts.



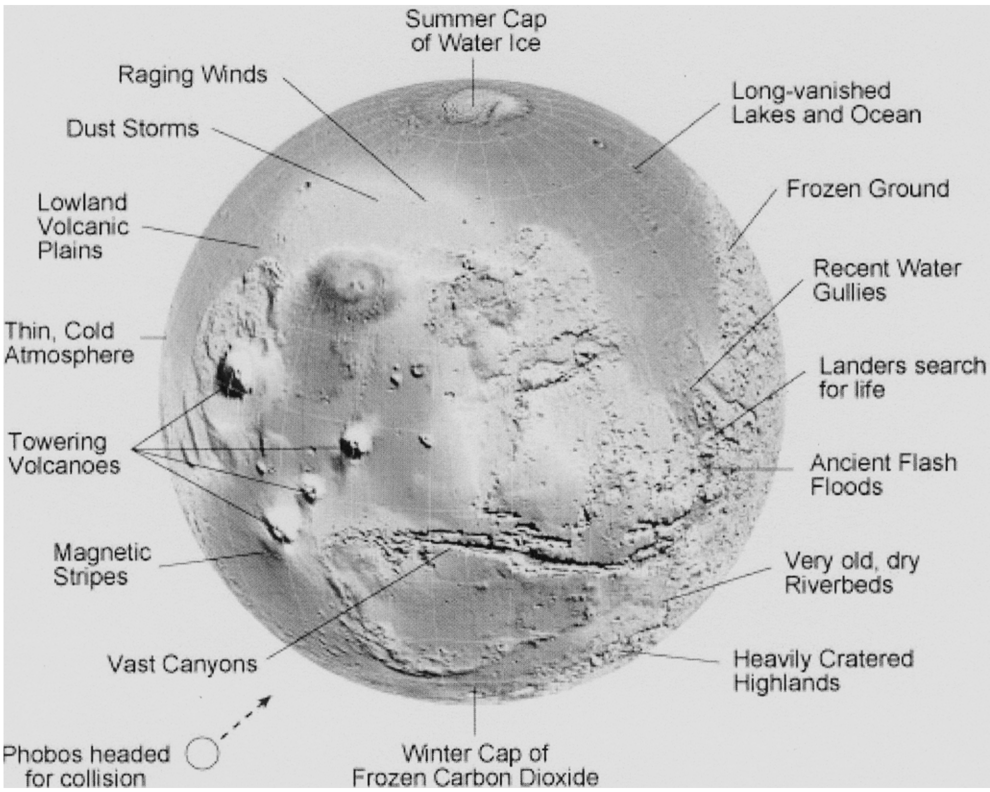


8. Mars: the red planet

- **Mars now has a thin, cold and dry atmosphere that is composed almost entirely of carbon dioxide.**
- **The low surface temperature and pressure of the Martian atmosphere are comparable to those in the Earth's stratosphere.**
- **The Martian atmosphere contains virtually no oxygen, so it has no ozone layer. The planet's surface is therefore exposed to the full intensity of the Sun's ultraviolet rays.**



Summary Diagram



NASA's Cosmos

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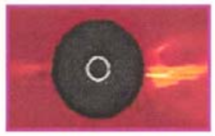
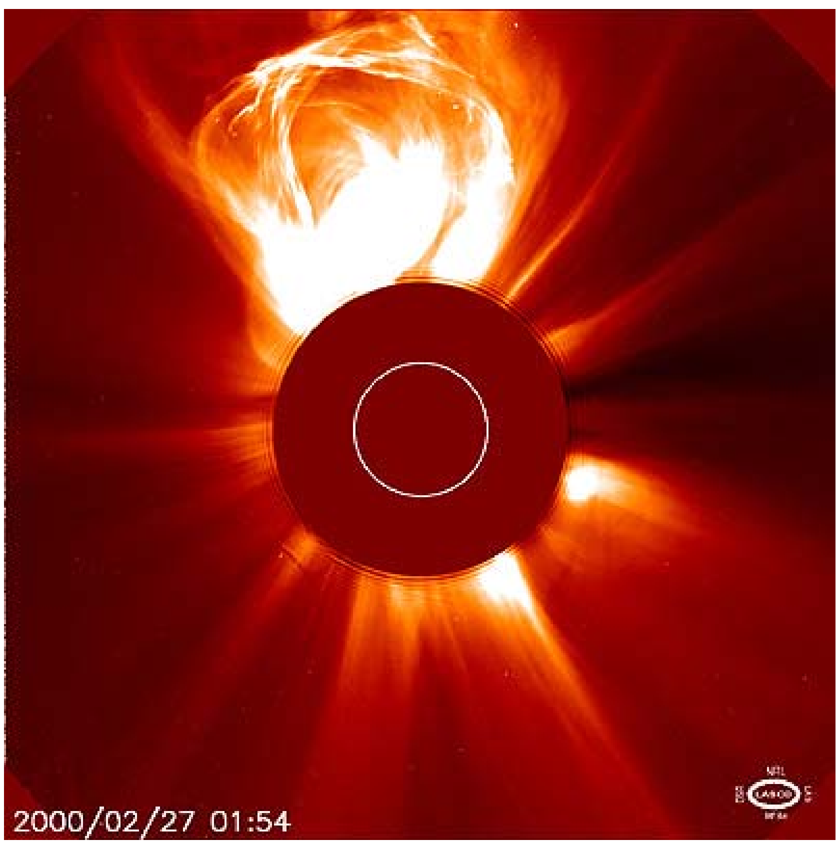
6. The explosive Sun



- The relatively calm solar atmosphere can be torn asunder by sudden, brief and intense outbursts called solar flares. They are the most powerful explosions in the solar system, releasing energies of up to 20 million 100-megaton terrestrial nuclear bombs (amounting to 10^{25} Joule or 10^{32} erg) in 100 to 1,000 seconds.

Coronol Mass Ejection



1. The Sun's domain

The planets are inside the expanding Sun

Our first clue to the existence of the solar wind came decades ago from comets. Touched by the Sun's warmth, a comet's ice and dust boil off, forming two tails that always point away from the Sun (Fig. 1.17). One is a yellow tail of dust and dirt, that litters the comets curved path. The dust is pushed away from the Sun by the pressure of sunlight. The other tail is electric blue, shining in the light of ionized particles. The straight ion tail acts like a wind sock that blows in the direction of the solar wind, and demonstrates the existence of this continuous electrified flow, streaming radially out in all directions from the Sun. Both comet tails always point away from the Sun, so they travel head first when approaching the Sun and tail first when departing from it.

Sound Paths

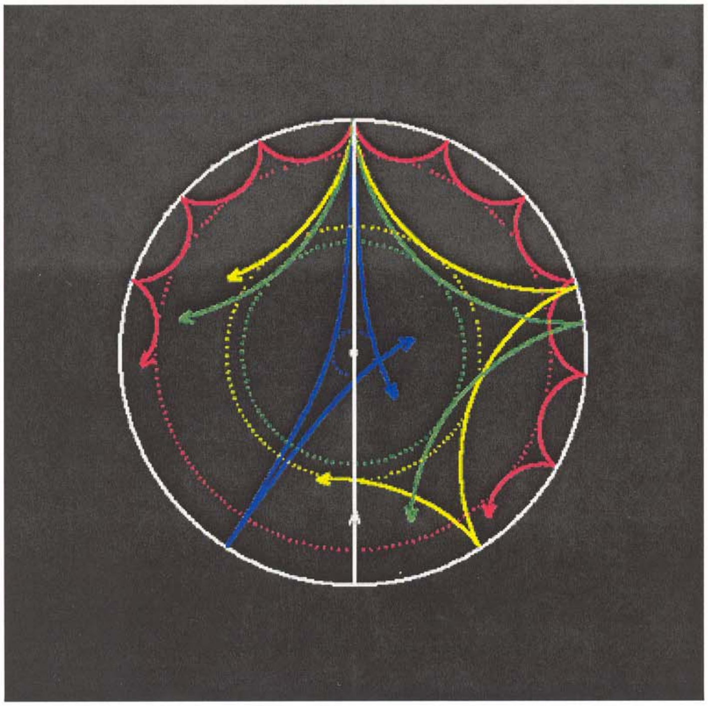


Fig. 4.5. Sound rays are bent inside the Sun, like light within the lens of an eye, and circle the solar interior in spherical shells or resonant cavities. Each shell is bounded at the top by a large density drop near the photosphere and bounded at the bottom by an increase in sound speed with depth that refracts a downward propagating wave back toward the surface. The bottom turning points occur along the dotted circles shown here. How deep a wave penetrates and how far around the Sun it goes before it hits the surface depends on the harmonic degree, l. The white curve is for $l = 0$, the blue one for $l = 2$, green for $l = 20$, yellow for $l = 25$ and red for $l = 75$. (Courtesy of Jørgen Christensen-Dalsgaard and Philip H. Scherrer.)

Internal Rotation of the Sun

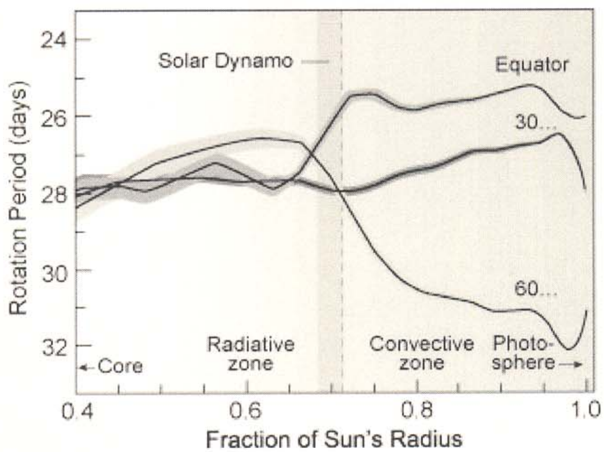


Fig. 4.8. The rotation rate inside the Sun at latitudes of zero (solar equator), 30 and 60 degrees has been inferred using data from the Michelson Doppler Imager (MDI) aboard the SOHO spacecraft. Just below the convection zone, the rotational speed changes markedly. The outer parts of the gaseous Sun rotate far faster at the equator than at the poles; this differential rotation persists to the bottom of the convection zone at 28.9 percent of the way down. Below that, uniform rotation appears to be the norm. Shearing motions along this interface may be the dynamo source of the Sun's magnetism. We don't know much about the rotation of the central parts of the Sun, within its energy-generating core, since most of the observed sound waves do not reach that far. (Courtesy of Alexander G. Kosovichev and the SOHO SOI/MDI consortium. SOHO is a project of international cooperation between ESA and NASA.)

The Ultraviolet Sun

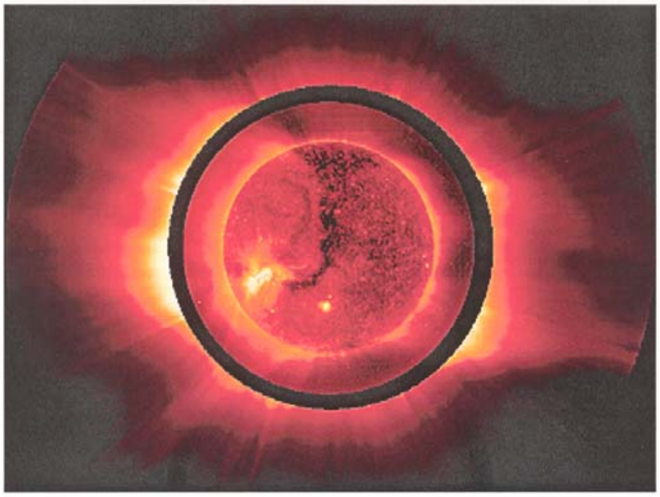


Fig. 5.30. This composite image, taken by two SOHO instruments and joined at the black circle, reveals the ultraviolet light of the Sun's atmosphere from the base of the corona to millions of kilometers above the visible solar disk. The region outside the black circle, obtained by UVCS, shines in the ultraviolet light emitted by oxygen ions flowing away from the Sun to form the solar wind. The inner image, obtained by EIT, shows the ultraviolet light emitted by iron ions at a temperature near two million degrees Kelvin. Dark areas, called coronal holes, are found at both poles of the Sun (top and bottom) and across the disk of the Sun; they are the places where the highest-speed solar wind originates. The structure of the corona is controlled by the Sun's magnetic field which forms the bright active regions on the solar disk and the ray-like structures extending from the coronal holes. [Courtesy of the SOHO UVCS consortium (outer region) and the SOHO EIT consortium (inner region). SOHO is a project of international cooperation between ESA and NASA.]

Layered rocks on Mars

Fig. 2.40a. These images from *Mars Global Surveyor* reveal hundreds of layers of similar thickness, texture and pattern that have been exposed in an impact crater in western Arabia Terra (*left*) and in a canyon located in southwestern Candor Chasma (*right*) of the Valles Marineris. The numerous, uniform deposits resemble regularly-layered, sedimentary rocks found on Earth. The Martian features could therefore be due to sediments that settled out of liquid water in ancient lakes or shallow seas a few billion years ago. The material might alternatively be due to deposits of airborne dust settling out of the atmosphere, that were later buried and compacted. Arabia is a peninsula of southwestern Asia, bordering the Persian Gulf, the Arabian Sea , and the Red Sea; terra means "extensive land mass"; candor is Latin for "glossy whiteness or sincerity", and chasma is "a deep, elongated, steep-sided depression". (Courtesy of JPL, NASA and Malin Space Science Systems.)

Martian gullies

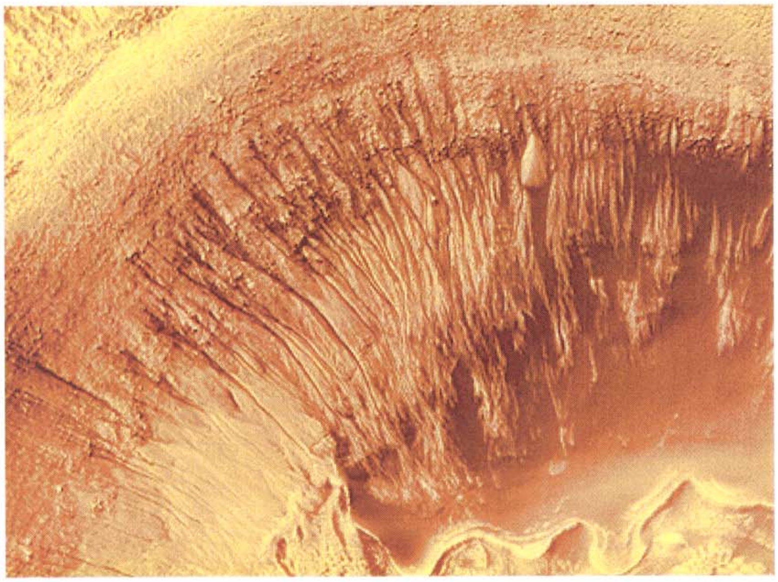


Fig. 8.41. Narrow gullies are eroded into the north wall of a small crater, about 7 kilometers across, that is itself located on the floor of the larger Newton Crater, named after the British scientist Isaac Newton (1643-1727). Flowing water may have caused these gullies and transported debris downhill, creating the lobed and finger-like deposits on the floor and at the base of the crater wall (*bottom center*). The individual deposits were used to estimate that 2.5 million liters, or 660 thousand gallons, of water flowed down each gully. This image, taken from the *Mars Global Surveyor*, is about 4 kilometers across, and centered at 41.1 degrees south and 159.8 degrees west. (Courtesy of NASA, JPL and Malin Space Science Systems.)

The Sun in X-rays

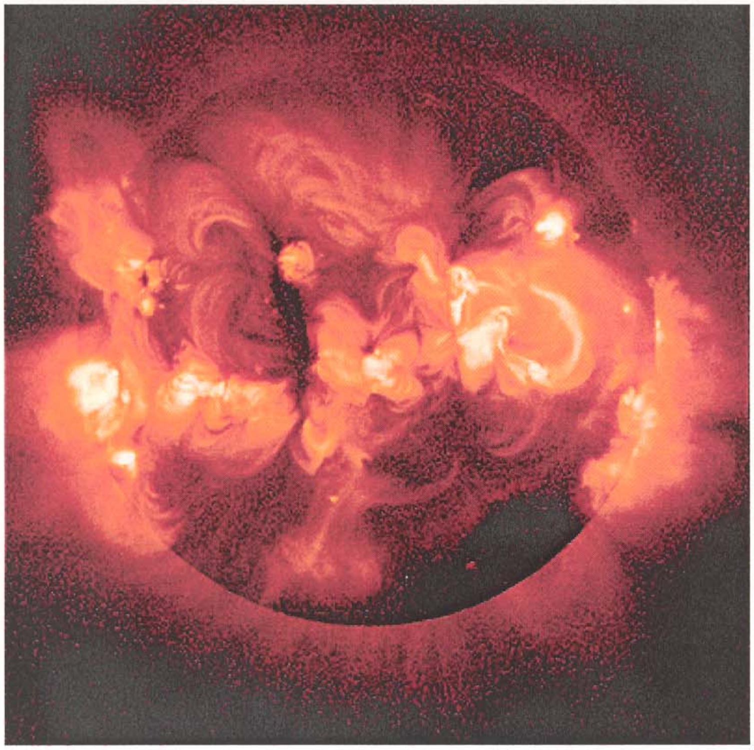


Fig. 5.26. The bright glow seen in this X-ray image of the Sun is produced by ionized gases at a temperature of a few million degrees Kelvin. It shows magnetic coronal loops which thread the corona and hold the hot gases in place. The brightest features are called active regions and correspond to the sites of the most intense magnetic field strength. This image of the Sun's corona was recorded by the Soft X-ray Telescope (SXT) aboard the Japanese Yohkoh satellite on 1 February 1992, near the maximum of the 11-year cycle of solar magnetic activity. Subsequent SXT images, taken about five years later near activity minimum, show a remarkable dimming of the corona when the active regions associated with sunspots have almost disappeared, and the Sun's magnetic field has changed from a complex structure to a simpler configuration – see Fig. 5.29. (Courtesy of Gregory L. Slater, Gary A, Linford, and Lawrence Shing, NASA, ISAS, the Lockheed-Martin Solar and Astrophysics Laboratory, the National Astronomical Observatory of Japan, and the University of Tokyo.)

Asteroid 433 Eros

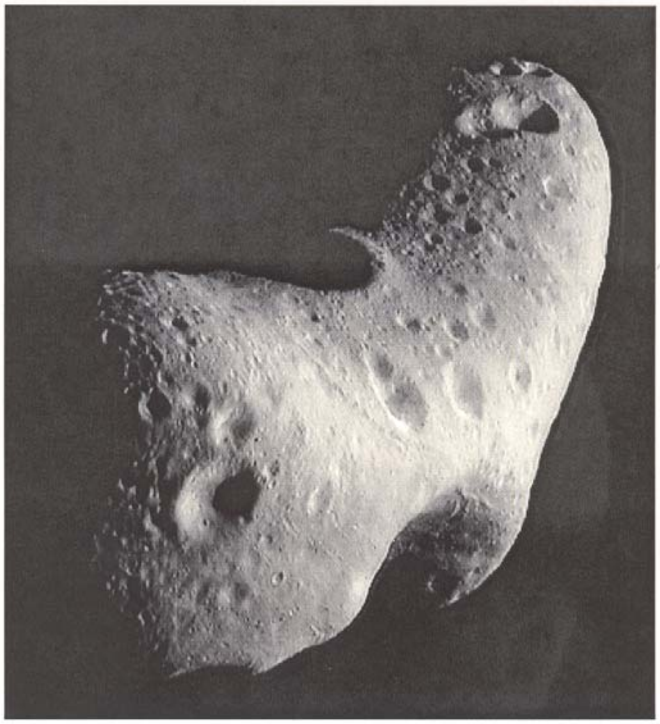


Fig. 13.13. This global view of the S-type asteroid 433 Eros was obtained by the *NEAR Shoemaker* spacecraft on 29 February 2000 from a distance of 200 kilometers. This perspective highlights the major features of the asteroid's northern hemisphere. The asteroid's largest crater (*top*) measures 5.5 kilometers wide and sits opposite from an even larger 10-kilometer, saddle-shaped depression (*bottom*). (Courtesy of NASA and the Johns Hopkins University Applied Physics Laboratory.)

Fatal impact

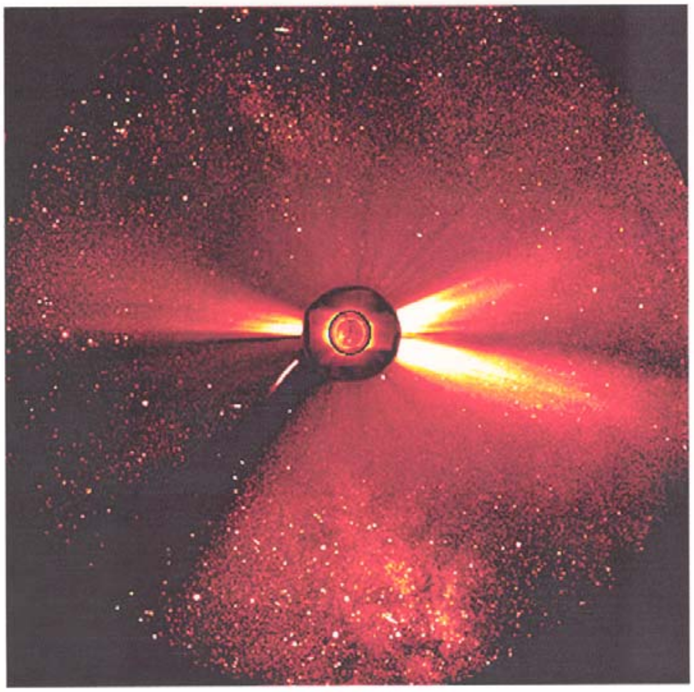


Fig. 14.5. This composite image records a comet plunging into the Sun on 23 December 1996. The innermost image (*center*) records the bottom of the million-degree solar atmosphere, known as the corona. The electrically charged coronal gas is seen blowing away from the Sun just outside the inner dark circle, which marks the edge of one instrumental occulting disk. Another instrument records the comet (*lower left*), as well as the coronal streamers at more distant regions and the stars of the Milky Way. (Courtesy of the *SOHO* EIT, UVCS and LASCO consortia. *SOHO* is a project of international collaboration between ESA and NASA.)

ATOMIC BOMBS TO STELLAR EXPLOSIONS
FUTURE: ATOMIC BOMBS TO EXPLODING STARS